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Health Consultation

Perchlorate Contamination in the Arden Cordova Water Service Area

AEROJET GENERAL CORPORATION

RANCHO CORDOVA, SACRAMENTO COUNTY, CALIFORNIA

CERCLIS NO. CAD980358832

APRIL 21, 1998

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

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In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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Prepared by:

California Department of Health Services
Under Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

BACKGROUND AND STATEMENT OF ISSUE

The Environmental Health Investigations Branch (EHIB) within the California Department of Health Services (CDHS), under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR), is conducting health assessment activities on the Aerojet-General Corporation (Aerojet) Superfund site in Sacramento County, California (See Figure 1). A Preliminary Health Assessment written in December 1988 recommended that when additional environmental information and data became available ATSDR would make another assessment (1). A Site Review and Update written in March 1993 also recommended a health assessment be conducted when more data became available (2).

This health consultation is one in a series that will be performed as part of the ATSDR health assessment process at this site. During this process, data and information on the release of hazardous substances and their impact on public health will be evaluated. Four health consultations have recently been written as part of this series (3-6). CDHS staff are in the process or writing a series of health consultations addressing the perchlorate contamination. In this health consultation, we will focus on describing the perchlorate contamination that has reached the Arden Cordova Water Service (Figure 2) and evaluating the health impact from the exposure that has occurred. We are also in the process of writing several other health consultations that focus on perchlorate exposure to consumers of water from other water purveyors in the area and from private wells in the area. In addition, we are also writing a health consultation that describes the perchlorate groundwater contamination west of the Aerojet Superfund site.

Aerojet began operation in 1951. Since that time, Aerojet has manufactured liquid and solid propellants for military and commercial rocket systems and has fabricated, assembled, tested and rehabilitated rocket engines (1). In addition, between 1974 and 1979, Cordova Chemical Company, a wholly-owned subsidiary of Aerojet, manufactured paint components, herbicides, and pharmaceutical products. Over the years, Aerojet and Cordova Chemical disposed of hazardous waste by burial, open burning, discharge into unlined ponds, and injection into deep underground wells (1). Some of these discharges, including perchlorate, have contaminated the environment have moved off-site of the Aerojet facility boundary (Figure 1). Perchlorate in the groundwater arises from ammonium perchlorate being a main component of solid rocket fuel. In addition to the natural migration of perchlorate-contaminated groundwater from the site, Aerojet is reinjecting treated water, contaminated with perchlorate, at the site's western boundary. The Regional Water Quality Control Board (RWQCB), the California Department of Toxic Substances Control (DTSC) and the U.S. Environmental Protection Agency (USEPA), are the lead regulatory agencies overseeing groundwater investigation and cleanup at Aerojet, and are also investigating other sources of the perchlorate, such as the McDonnell Douglas (now Boeing) and Purity Oil Sales sites.

The Arden Cordova Water Service is one of thirty-eight water systems that compose the Southern California Water Company. Southern California Water Company is a public utility

company engaged principally in the production, transmission, distribution, and sale of water to over 240,000 customers, or one out of 30 persons in the State of California. The company stock is traded on the New York Stock Exchange.

The Arden Cordova Water Service is composed of two distinct systems, the Arden System and the Cordova System (Figure 1). These systems are not interconnected, ie. the wells located in the Cordova System serve only the Cordova System customers. The Cordova System has been impacted by the perchlorate contamination whereas the Arden System is located several miles west of the contamination, and thus it is unlikely that it will ever be affected. In the rest of the document, we will only be discussing the Cordova System.

The Cordova System supplies water to 11,650 connections, approximately 36,500 customers, mostly family residences and commercial businesses (7). During the rainy, cool months, groundwater supplies all the water for the Cordova System (8). In the hot, dry months (May to November), the Cordova System water comes from a combination of 33% surface water and 67% groundwater (8). The surface water undergoes conventional treatment for pathogen and turbidity removal after it is drawn from the Folsom South Canal, which diverts water from the American River at Nimbus Dam, below Folsom Reservoir. Prior to the discovery of the perchlorate, the groundwater was drawn from 19 wells (Numbered 1-21, no #2 or #9, see Table 1). All of these wells are located within the Cordova System (Figure 2). Generally speaking, these wells are screened from approximately 200 to 500 feet below ground surface (9). Prior to the perchlorate contamination discovery, the Cordova System did not receive water from any other sources or interties with other water systems, except at one site. The intertie with the City of Folsom was designed be used during peak demand up to 2,400 gallons per minute but not to exceed 300,000 gallons per day.

All water sources serve a single pressure zone with an elevation range of approximately 70 feet (7). The distribution system consists of over 370,000 feet (or 70 miles) of pipe ranging in size from 4 to 24 inches in diameter. There are two clear well/reservoirs in the system which have a total storage capacity of two million gallons. There are a total of 18 low and high lift pumping facilities at the water treatment plants.

All the wells (and the new intertie) are interconnected in a complex system in which distribution of the water is based on demand within the system. In fact, some wells are not typically used, unless supply demands that they start pumping water (Table 1). The water that most Cordova System residents receive is probably a mixture of water from more than one well (or intertie). However, if a house or building is located right next to a well that is pumping, then that house or building probably receives 100% of its water from that well.

One well, Well #21 has a sand/anthracite filter for removing manganese, and controlling hydrogen sulfide odor (7). There are plans to have filters installed at the sites of Well #11 and #12 for manganese treatment and removal by the end of the 1997.

The highest level of nitrate found in the Cordova System wells is 19 ppm nitrate as nitrogen, with the average being 7.4 ppm (10). The drinking water standard for nitrate is 20 ppm. The drinking water standard for nitrate is 45 ppm.

In the 1980s, trichloroethylene (TCE) was found to have contaminated Arden Cordova wells 13, 15, and 16 (10). Freon 113, cis and trans-1,2-dichloroethylene, 1,1-dichloroethylene, and 1,1-dichloroethane have also been detected in well #16. The wells have continued to be used because Aerojet provided groundwater treatment units to cleanup the water pumped from these wells (8). Aerojet installed carbon treatment on well #16 in February 1985 and installed treatment systems on well 13 and 15 in 1986. Since 1990, TCE has also been detected in Well #9; the highest concentration detected was 5.0 ppb in June 1994 (10). Arden Cordova took well #9 off-line in September 1995 (8) and the well casing was filled with concrete (destroyed) in November 1997. TCE has also been detected in Wells #11 (up to 2 ppb) and 14 (up to 2 ppb).

DISCUSSION

In late January and early February 1997, Aerojet, as a part of their ongoing monitoring of certain off-site public drinking water wells, detected perchlorate in five off-site public drinking water wells west of Aerojet (11). To analyze these water samples, Aerojet used a refined or improved analytical method such that instead of a detection level of 400 ppb, they were able to obtain a detection limit of 35 ppb.

Of these five wells that were contaminated with perchlorate, three wells (Wells 13, 15, 16) are a part of the Cordova System (Figure 3). In February 1997, the concentrations in Cordova wells 13, 15, and 16 were reported as 220, 95, and 210 ppb perchlorate, respectively (11). Subsequent re-testing of the wells showed comparable levels. These detectable levels of perchlorate exceed the concentration (4 to 18 ppb) suggested by the USEPA provisional reference dose (1 to 5E-4 mg/kg/day) based on a 70 kg individual consuming 2 liters of water a day (12).

Southern California Water Company immediately shut the three Cordova System wells off after being notified by Aerojet on February 11, 1997 of the perchlorate levels (8). Because the Cordova Water Service Area wells are interconnected, water from other wells was used to supply those who had previously gotten water from wells 13, 15, and 16.

In March 1997, the Sacramento District field staff of the CDHS Division of Drinking Water (DDW) began sampling public water supply wells in the area of the known perchlorate contaminated wells. The well samples are processed by the CDHS's Radiation and Sanitation Laboratory with a detection limit of 4 ppb. In March, DDW staff sampled 41 public supply wells, including 18 Cordova System wells (13). On April 8, 1997, DDW staff notified the Southern California Water Company of the perchlorate levels found in wells 11 (4.4 ppb), 14 (4.4 ppb), and 19 (6.8 ppb). Since these wells exceeded 4 ppb, the low end of the acceptable

range based on USEPA's provisional reference dose range, Southern California Water Company discontinued using these wells on April 8, 1997 (8).

In May, DDW headquarter staff reviewed the USEPA's provisional reference dose range and decided to adopt the drinking water concentration estimated from the upper end of USEPA's acceptable provisional reference dose range as the concentration (18 ppb perchlorate) at which the water purveyor would have to notify their water customers if they were to deliver the water to them (see Attachment A). After an independent review of perchlorate toxicity when using the use of the upper limit of the acceptable range (18 ppb), Arden Cordova placed wells 11, 14, and 19 back into service on June 19, 1997 (8). All three wells have levels of perchlorate in the well water between 4 and 12 ppb perchlorate.

The DDW field staff have continued to play the lead role in monitoring the perchlorate contamination in drinking water sources. In April, DDW staff sampled 22 wells, including 8 Cordova System wells (13). In May, DDW staff sampled 43 locations, including 18 Cordova System wells and the Cordova Systems raw influent from the Folsom South Canal (13). In June, DDW staff sampled 47 locations, including 18 Cordova System wells and the untreated influent from the Folsom South Canal (13). In July, DDW staff analyzed water from 40 locations, including 16 wells Cordova System wells and the raw influent from the Folsom South Canal (14). In August, DDW staff analyzed water from 42 locations, including 19 wells Cordova System wells and the raw influent from the Folsom South Canal (15). The Folsom South Canal influent does not have detectable levels of perchlorate (data not shown). No other Cordova System wells have been identified that have perchlorate levels exceeding 18 ppb perchlorate (Table 1). As stated previously, three Arden Cordova wells, which have levels between 4 and 18 ppb, are again in use. Perchlorate has been detected but not quantified (means that it is less than 4 ppb), in Cordova System wells #1, 3, 4, 6, 7, and 21.

Community Concerns

In March 1997, soon after they became aware of the potential perchlorate contamination, Southern California Water Company sent a letter to all of their Cordova System customers notifying them of the problem and announcing a public meeting on March 18, 1997 at which they would disseminate more information about the contamination (see Attachment B).

At the meeting, a panel of experts, invited by Southern California Water Company, presented and responded to the origin of the perchlorate contamination, perchlorate toxicity, and water quality and service issues. Approximately 100 people attended the meeting on March 18, 1997. The meeting was well covered by the written and television press. The audience had a number of questions and statements concerning water quality, health concerns, water supply, and what was being done to make Aerojet fix the problem. At one point, a woman who has a thyroid problem asked those people in the audience to raise their hand if they had a thyroid problem, and it seemed that a significant portion of the audience responded.

Aerojet sent letters to everyone that attended the March 18th meeting and to people on their mailing list in which they invited interested persons to attend a public meeting on April 17, 1997. The focus of the April meeting organized by Aerojet was thyroid function and perchlorate toxicity. At this meeting, CDHS cooperative agreement staff responded to requests for health studies raised by the community by announcing that we were pursuing a review of available health statistics. After the meeting, CDHS cooperative agreement staff were approached by several concerned people, including a medical director of a company with a large number of employees working within the Cordova Water Service Area. The medical director was interested in getting as much information about perchlorate toxicity as possible and requested a fact sheet about perchlorate toxicity that could be shared with the employees.

The Central Valley Regional Water Quality Control Board (RWQCB) conducted a public workshop on the perchlorate issue on April 22, 1997. The RWQCB staff presented to the board an overview of the perchlorate contamination emanating from Aerojet General Corporation, and perhaps Purity Oil and McDonnell Douglas properties. During the comment period, CDHS cooperative agreement staff spoke briefly about the known and unknowns of perchlorate toxicity. The Air Force informed the board of their commitment to fund several studies to more thoroughly investigate perchlorate toxicity. Several water purveyor representatives asked the board to consider restricting any further reinjection of perchlorate-contaminated water from Aerojet water treatment facilities. The RWQCB staff responded that stopping reinjection at this time would not affect the movement of perchlorate-contaminated groundwater in the near future; however, continued treatment of the groundwater for trichloroethylene and other volatile organic chemicals is critical to stopping their continued movement. Quite a few members of the public gave comments regarding health concerns about the perchlorate. The board encouraged everyone involved to communicate often with the public about the perchlorate issues.

In April, CDHS cooperative agreement staff prepared a draft of a fact sheet focusing on perchlorate and health issues (see Attachment C). CDHS cooperative agreement staff asked for comments on a draft fact sheet DDW staff, RWQCB staff, and all water purveyors including Southern California Water Company. CDHS made the final perchlorate fact sheet available in hard copy and electronic format to Southern California Water Company and to the medical director who was interested in receiving such information.

Since the first letter sent to each customer in the Cordova System, the Southern California Water Company has put two notices in the local newspapers (see Attachments D and E). On April 29, 1997, Southern California Water Company issued a public notice reiterating the closure of the three wells with higher amounts of perchlorate and also notifying the public that three additional wells had been taken out of service when the March DDW water sampling results had shown these three wells to be contaminated with lower levels of perchlorate. In mid July, the Southern California Water Company notified their customers through a public notice that based on DDW's reevaluation of the provisional action level for perchlorate in drinking water and raising of the level from 4 to 18 ppb, they had restored the use of the three wells that had levels between 4 and 18 ppb. In the notice, Southern California Water Company referred interested people to their

web site for water quality information and the fact sheet on perchlorate and health created by CDHS cooperative agreement staff. They also made the CDHS perchlorate fact sheet available at their offices or by mail.

Exposure Pathways

It is not clear when the perchlorate contamination reached the Cordova System wells, because Aerojet had previously been using an analytical method to monitor for perchlorate that was not sensitive enough to adequately assess the migration of perchlorate. In fact, until recently, Aerojet had a perchlorate reporting level to RWQCB of 400 ppb, based on the fact that the older method had a practical quantitation limit for perchlorate of 400 ppb (16). It was not until Aerojet improved upon the analytical method they had been using and were able to obtain lower detection limits, that the perchlorate contamination could be adequately addressed.

Though we do not have good monitoring information, we do know that Aerojet began reinjecting water from their treatment plants on the west boundary of the site in 1984 and 1985, which continues to this day (17). Thus, assuming that it took a couple of years for the perchlorate to move from the reinjection wells to the Cordova System wells, perchlorate has probably been a contaminant in the Cordova System wells since 1987.

The exposure to the perchlorate contamination in Cordova System wells #13, #15, and #16 ceased on February 11, 1997 when Aerojet notified Southern California Water Company of the perchlorate contamination and Southern California Water Company immediately took them off-line (8).

Three other Cordova System wells (Cordova System wells #11, #14, and #19) have had levels of perchlorate between 4 and 11 ppb measured in the well water. Southern California Water Company took these wells off-line on April 8, 1997 because the levels exceeded 4 ppb, but placed them back on-line on June 19, 1997 because the levels did not exceed 18 ppb (8). Several other wells have had detectable but not quantifiable levels (<4 ppb) of perchlorate (Table 1).

The Cordova System wells provide water to 11,650 connections, approximately 36,500 customers, mostly residents (7). However, residential and commercial users closest to the wells with the highest exposure (Cordova System wells #13, 15, or 16) are likely to have had the highest exposure (8). Similarly, exposure to lower levels of perchlorate occurred and still occurs to the residents and commercial users closest to Cordova System wells #11, 14, and 19.

For a target population to be exposed to environmental contamination, there must be a mechanism by which that contamination comes into direct contact with the target population. An exposure pathway is the description of this mechanism (18). A completed exposure pathway consists of five parts: a source of contamination, an environmental medium and

transport mechanism, a point of exposure, a route of exposure, and a receptor population. For a population to be exposed to an environmental contamination, a completed exposure pathway (all five elements) must be present.

In the next few paragraphs, CDHS will describe how we evaluated the completed exposure pathway related to the perchlorate contamination of the Cordova System for three receptor populations: residential, worker, and frequent customer/visitor exposure to Cordova System well water (Table 2), assuming that these receptor populations live/work/visit a house or business that is located directly next to the perchlorate contaminated wells (Cordova System wells #11, 13, 14, 15, 16, and 19). In essence, we are examining only those scenarios in which the house or business is receiving 100% of their water from one well. As described in the background section, most Cordova System customers get water that comes from more than one source, and thus the exposure scenarios that we will evaluate may not reflect the exposure for a resident/employee/visitor who lives/works/visits a house or building that is not located right next to a perchlorate-contaminated well. We hope to more adequately address the complexity of exposure through exposure dose reconstruction (see Recommendations section), but in this health consultation we will only consider the exposure pathway scenarios described in this paragraph.

When evaluating the potential health impact from exposure to contaminated potable water, CDHS considered all routes of exposure to perchlorate in the water. The most important route of exposure is through ingestion of the water. We did not evaluate exposure from eating homegrown fruits and vegetables that were irrigated with perchlorate-contaminated water, because we were not aware of bioconcentration parameters related to perchlorate (there are investigations into this issue, see Public Health Recommendations and Actions Section). We did not evaluate inhalation exposure to perchlorate in the potable water because perchlorate is not volatile (does not become a gas).

For certain chemicals, skin contact with contaminated water can be an important route of exposure. Generally speaking, skin absorption of a chemical is based on how much that chemical likes to be in fat-like surroundings. Inorganic ions like perchlorate do not like being in fat-like surroundings and thus their uptake by the skin, a fat-like environment, are typically less than 10% and frequently less than 1%. Since the permeability characteristic for perchlorate is not known, we used the permeability characteristic of another anion, chloride (1×10^{-10} cm/sec) to evaluate skin exposure to perchlorate (19). We found that skin contact would result in an exposure dose estimate that is less than 0.0005% of the dose estimate that would be received by ingesting the water. Therefore, CDHS focused on ingestion in calculating dose estimates.

The amount of Cordova System perchlorate-contaminated water that is ingested will be determined for each exposure pathway. In this analysis of exposure through ingestion, it will be assumed that there is 100% absorption of perchlorate into the body from the gut from the amount water that is ingested.

Toxicological Evaluation

This health consultation focuses on perchlorate exposure and thus the toxicological evaluation will focus on perchlorate. CDHS acknowledges that there low levels (below the drinking water standard) nitrates and nitrite, naturally-occurring and agriculturally-related, in the well water; however, the affect of nitrates/nitrites in combination with perchlorate will not be evaluated due to lack of toxicological information that would allow such an evaluation.

Most of the information about the toxicity of perchlorate comes from studies of potassium perchlorate as a treatment for hyperthyroidism, resulting from Graves' Disease. Perchlorate inhibits the secretion of thyroid hormones (and can thus relieve the symptoms of Graves' Disease) by competitively inhibiting the accumulation of iodide in the thyroid (20). Discontinued administration of the ammonium perchlorate to Graves' Disease patients does result in a return to their hyperthyroid condition (21). People who have been treated with perchlorate have reported gastrointestinal irritation, skin rash, and hematological effects including agranulocytosis, aplastic anemia, and lymphadenopathy (20). The severe hematological effects seem to be more likely to occur when large doses of more than 1,000 mg/day (approximately 14 mg/kg/day for a 154 pound man) are used (22).

Potassium perchlorate was extensively used for treatment of Graves' Disease patients in the late 1950s and 1960s. After the reports of the severe hematological effects, potassium perchlorate was not used for many years (23). In the early 1980s, physicians in Europe began using it again for the treatment of Graves Disease, and reporting no serious side effects occurring as long as the dose was kept below 1,000 mg/day (approximately 14mg/kg/day for a 154 pound man)(22). In addition, potassium perchlorate has also been found helpful in treating thyrotoxicosis resulting as a side effect from other drug therapies (24-28).

There are only a few studies of the short-term exposure in persons without Graves Disease (29). The animal studies that have been conducted have also involved short-term exposures and the doses were too high to see a level where there was no effect on the thyroid. Both human and animal studies have primarily examined the effects of perchlorate on the thyroid, interference with the production of thyroid hormones resulting in a below normal level of thyroid hormone in circulation (hypothyroidism). The effect of perchlorate on systems other than the thyroid needs to be explored, especially, effects on the blood system (described above) and developmental effects (described below).

Children are not little adults, their bodies are not fully developed, and may not respond to a perchlorate in the same manner as an adult. For instance, thyroid hormone is critical to normal brain and physical development, and the critical period for this dependency on thyroid hormone begins in the uterus and extends up until three years of age. After the age of 3, thyroid hormone continues to play a primary role in physical development until puberty. Thus, a low level or absence of thyroid hormone in utero or in childhood may lead to irreversible mental retardation and retarded physical growth.

Perchlorate can cross the placenta and thus could affect the developing fetus, though these effects have not been studied in humans. It is known, however, that drugs currently being used to treat Graves' Disease such as propylthiouracil do cross the placenta and can produce neonatal hypothyroidism (30, 31) and fetal in utero goiter (enlargement of the thyroid)(32-34). In fact, because the developing fetus's thyroid is immature, propylthiouracil is a more potent suppressor of thyroid function in the fetus than in the mother (35).

In a study of the effects of potassium perchlorate (740mg/kg/day for the mother) fed to pregnant guinea pigs during pregnancy, a 15-fold enlargement of thyroid of the newborns was noted, even though no increase in size of the mother's thyroids occurred (36). Thyroid hormone levels of the newborn guinea pig were not measured in this study. Another animal study in which the mother was given fairly high levels of perchlorate, also resulted in increased thyroid weight in the offspring and the mother (37). At this time, it is unclear whether lower doses of perchlorate would affect the thyroid of the developing fetus and young child and thus affect thyroid function at a time when normal thyroid hormone production is important to brain development.

There are animal studies underway which are exploring the toxicity of perchlorate, including effects on the immune system and developmental effects (see the Recommendations section at the end of the text for more information).

In 1992 and 1995, USEPA staff reviewed the perchlorate toxicology studies and derived a provisional reference dose (RfD)(12, 29). An RfD is a dose to which a person could be exposed over long-term period without having any appreciable risk of a noncancer health effect. The USEPA applied an uncertainty factor of 300 or 1000 to the No Observable Adverse Effect Level of 0.14 mg/kg/day (NOAEL)(29, 38) to derive an RfD of 1 to 5 x 10-4 mg/kg/day (12). (If one assumes that a person drinks 2 liters/day of water and weighs 70 kilograms, the reference dose range corresponds to an acceptable range of perchlorate in drinking water of 4 to 18 ppb).

The uncertainty factor of 300 or 1000 is derived from multiplying the following (12):

* An uncertainty factor of 10 to account for extrapolation from the acute exposure in the NOAEL study to chronic exposure of an RfD;

* An uncertainty factor for database deficiencies (3 or 10) to account for data limitations including limited data on subchronic and chronic exposure to low doses of perchlorate, limited data on other organ system effects, limited data on the effects on the hematopoietic system, and a lack of reproductive and multigenerational data;

* An uncertainty factor of 10 to protect sensitive subpopulations which would include groups such as hypothyroid patients and individuals with low iodine

diets or with genetically impaired iodine accumulation.

The only information about the possible carcinogenicity of perchlorate has to do with cancers of the follicular thyroid cells (12). Interference with the normal thyroid-pituitary feedback mechanism, such as that caused by perchlorate, can theoretically lead to thyroid follicular cell neoplasia. Several animal studies found that thyroid tumors were induced in both rats and mice by long-term administration of high doses of perchlorate. However, humans are not supposed to be as sensitive as the rat to thyroid cancer (39, 40). Since perchlorate's possible carcinogenic effects on the thyroid are based on the same mechanism (interfering with the thyroid-pituitary homeostasis) that determines its noncarcinogenic effects, it may be appropriate to consider the RfD as a dose which does not pose a significant risk of thyroid cancer (29).

It is even harder to determine whether or not perchlorate exposure can cause any other type of cancer. If a link is discovered, it will probably be based on perchlorate acting not as a mutagen (causing genetic changes) but rather as a growth promoter, an effect associated with a threshold. In other words, below a certain threshold, perchlorate would not have cancer-causing effects. More toxicological information is needed to ascertain whether perchlorate can cause cancer and if it can, at what dose this effect may start occurring.

Using USEPA's provisional reference dose (0.0001 to 0.0005 mg/kg/day) based on perchlorate's effect on the thyroid, CDHS evaluated the noncancer (thyroid) health impact of the completed exposure pathway, drinking water containing perchlorate from Cordova System wells, for three receptor populations: adult resident, worker, and frequent adult customer/visitor (Table 2). For wells no longer in service, the last concentration of perchlorate measured in the well before the well was taken off-line was used. If a well is in service, the highest concentration of perchlorate measured in the well when it was on-line was used in the dose calculations.

Though it is possible to estimate a dose for a child drinking the Cordova System water, CDHS did not calculate this dose because we are not confident about how to interpret the dose estimate. To compare the estimate of a child's dose with toxicological information based on adult exposure ignores the fact that a child is not a small adult, especially when it comes to the importance of the thyroid in normal brain development (see above). Thus, until there is more information about perchlorate's effect on children, CDHS is not able to evaluate past and current exposures to a young child drinking the Cordova System water.

Residential exposure in the Cordova System: CDHS estimated the exposure for a adult resident who lives 24 hours per day, seven days a week, for 52 weeks of the year near Cordova System wells #11, 13, and 14 (Table 3 is a list of the exposure parameters used in the toxicological evaluation). Concentrations in wells #11, 13, and 14 were used for the dose calculations of the residential exposure because these wells primarily serve residences. CDHS will assume that the adult resident drinks 2 liters/day. CDHS estimated doses for a adult

resident exposed to water coming from Cordova System wells #11, 13, and 14 with contaminant levels of 4.4, 220, 4.4 ppb, respectively.

The estimated dose for adult residential exposure to water from Cordova System wells #13 (0.0063 mg/kg/day) exceeds the provisional reference dose range (0.0001 to 0.0005 mg/kg/day) which means that noncancer (thyroid depression) health effects may have occurred when adult residents who lived close to Cordova System wells #13 were exposed to the perchlorate-contaminated water from these wells. However, because there is a very large uncertainty factor associated with the provisional reference dose and the estimated dose does not approach the NOAEL (0.14 mg/kg/day), it is unlikely that the adult residential exposure to well #13 did cause any noncancer health effects.

The Southern California Water Company took well #13 out of service on February 11, 1997, so there is no current or future exposure to well #13 water. Since it is thought that the effect of perchlorate on thyroid function returns to normal after exposure to perchlorate ceases, any effects that may have occurred to adult residents receiving water from well #13, should no longer be occurring.

The estimated dose for the adult resident exposed to water from well #11 (0.0001 mg/kg/day) or 14 (0.0002 mg/kg/day) does not exceed the provisional reference dose range (0.0001 to 0.0005 mg/kg/day). This means that noncancer (thyroid depression) health effects would not have occurred or should not be occurring to the adult resident drinking or washing with water from well #11 or 14. Wells #11 and 14 are currently in service.

Worker exposure in the Cordova System: CDHS will estimate the exposure for a worker who works eight hours a day, five days a week, for 50 weeks of the year (assumes a two week vacation) at a business that is served by Cordova System wells #15, 16, and 19 (Table 2 is a list of the exposure parameters used in the toxicological evaluation). Concentrations in wells #15, 16, and 19 were used for the dose calculations of the worker exposure because these wells primarily served commercial connections. CDHS will assume that the worker is involved in manual labor and thus drinks a relatively large quantity of water each day (3.7 liters (15.6 cups)(41). CDHS will estimate the dose if the worker is exposed to water coming from Cordova System wells #15, 16, and 19, with contamination levels of 95, 220, and 6.8 ppb, respectively.

The estimated dose for worker exposure to water from Cordova System wells #15 (0.0011 mg/kg/day) or #16 (0.0027 mg/kg/day) exceeds the provisional reference dose range (0.0001 to 0.0005 mg/kg/day) which means that noncancer (thyroid depression) health effects may have occurred when workers of businesses located close to Cordova System wells #15 or #16 were exposed to the perchlorate-contaminated water from these wells. However, because there is a very large uncertainty factor associated with the provisional reference dose and the estimated doses do not approach the NOAEL (0.14 mg/kg/day), it is unlikely that these exposures did cause any noncancer health effects.

The Southern California Water Company took wells #15 and 16 out of service on February 11, 1997, so there is no current or future exposure to well #15 or 16 water. Since it is thought that the effect of perchlorate on thyroid function returns to normal after exposure to perchlorate ceases, any effects that may have occurred to workers receiving water from well #15 or 16, should no longer be occurring.

The estimated dose for the worker exposed to water from well #19 (0.0001 mg/kg/day) does not exceed the provisional reference dose range (0.0001 to 0.0005 mg/kg/day). This means that noncancer (thyroid depression) health effects would not have occurred to the worker drinking or washing with water from well #19. Well #19 is currently in service.

Frequent customer or visitor exposure to Cordova System businesses: CDHS will estimate the exposure for an adult visitor or customer who goes once a day, five days a week, for 50 weeks of the year (assumes a two week vacation) to a business that is served by Cordova System wells #15, 16, and 19 (Table 2 is a list of the exposure parameters used in the toxicological evaluation). Concentrations in wells #15, 16, and 19 were used for the dose calculations of the frequent adult customer/visitor exposure because these wells primarily serve commercial connections. CDHS will assume that the adult customer/visitor drinks one cup of water (0.24 liters) per trip to the business. CDHS will estimate the dose if the frequent adult customer/visitor is exposed to water coming from Cordova System wells #15, 16, and 19, with contamination levels of 95, 220, and 6.8 ppb, respectively.

The estimated dose for the frequent adult customer/visitor exposed to water from well #15 (0.0002 mg/kg/day), #16 (0.0005 mg/kg/day), or #19 (0.000016 mg/kg/day) does not exceed the provisional reference dose range (0.0001 to 0.0005 mg/kg/day). This means that noncancer (thyroid depression) health effects would not have occurred to the frequent adult customer/visitor drinking or washing with water from well #15, 16, and 19. Wells #15 and 16 have been taken out of service. Additionally, drinking the water from Cordova System well #19, which is being used, should not cause noncancer health effects to occur.

The estimated dose for the frequent adult customer/visitor exposed to water from well #19 (0.000016 mg/kg/day) does not exceed the provisional reference dose range (0.0001 to 0.0005 mg/kg/day). Thus, noncancer (thyroid depression) health effects would not have occurred or should not be occurring to the adult customer/visitor drinking or washing with water from well #19.

CONCLUSION

Based upon the information reviewed, there was and is a completed exposure pathway to perchlorate-contaminated water in the Cordova System. Adult residents who lived near and employees who worked at businesses near the contaminated wells may have been or may be exposed on a regular basis to the perchlorate when they drank water and washed or showered with the water. Other exposures occurred over a short duration resulting in a very low dose to

the customers and visitors who occasionally frequented the business establishments located near the perchlorate-contaminated wells.

It is hard to say when the perchlorate first contaminated the Cordova System wells but it may have been as early as 1987. As a result of being notified of the perchlorate contamination on February 11, 1997, Southern California Water Company stopped the distribution of water with levels of perchlorate greater than 18 ppb (USEPA's provisional reference dose based on a 70 kg individual consuming two liters of water a day). The water from several Cordova System wells that are currently in use contain perchlorate in lower concentrations (<18 ppb).

Since the uncertainty factors are supposed to account for the somewhat limited toxicological information, it is conceivable that as more toxicological data becomes available, a change in the (provisional) reference dose may occur.

The estimated dose for a adult resident exposed to water from well #13 or a worker exposed to well #15 or 16 exceed the provisional reference dose range which means that noncancer (thyroid depression) health effects may have occurred when the adult resident was exposed to water from these wells. However, because there is a very large uncertainty factor associated with the provisional reference dose and the estimated doses do not approach the NOAEL, it is unlikely that these exposures did cause any noncancer health effects. These wells are no longer being used, thus any noncancer health effects that may have occurred should no longer be occurring now that the exposure has ceased.

The estimated dose for a frequent adult customer/visitor exposed to water from well #15 or 16 does not exceed the provisional reference dose range. This means that noncancer (thyroid depression) health effects would not have occurred to the frequent adult customer/visitor drinking or washing with water from well #15 or 16.

The estimated dose for adult resident exposed to water from well #11 or 14 does not exceed the provisional reference dose range. This means that noncancer (thyroid depression) health effects would not have occurred or should not be occurring to the adult resident drinking or washing with water from well #11 or 14. The estimated dose for worker or a frequent adult customer/visitor exposed to water from well #19 does not exceed the provisional reference dose range. This means that noncancer (thyroid depression) health effects would not have occurred or should not be occurring to the worker or a frequent adult customer/visitor drinking or washing with water from well #19. Wells #11, 14, and 19 are currently in use.

Based upon the information available at the time this health consultation was written, CDHS concludes that well water from Cordova System wells #13, 15, and 16 may have posed a health hazard when these wells were in use. Since the water from these three wells are no longer being used, these wells do not pose a current health hazard. Additionally, the perchlorate levels in the other Cordova System wells that are currently in use do not pose a health hazard.

PUBLIC HEALTH RECOMMENDATIONS AND ACTIONS

The Public Health Recommendations and Actions Plan (PHRAP) for this site contains a description of actions taken, to be taken, or under consideration by ATSDR and CDHS or others at and near the site. The purpose of the PHRAP is to ensure that this health consultation not only identifies public health hazards, but also provides a plan of action designed to mitigate and prevent adverse human health effects resulting from exposure to hazardous substances in the environment. The CDHS and ATSDR will follow-up on this plan to ensure that actions are carried out.

Actions Completed

1. Southern California Water Company immediately discontinued the delivery of perchlorate contaminated water and now is only delivering water with less than 18 ppb perchlorate.

2. Southern California Water Company has communicated with the Cordova System water customers by holding a workshop and has released several public notices to keep their customers informed about the perchlorate problem.

3. CDHS prepared a fact sheet about perchlorate and health. CDHS made this fact sheet available to the affected water purveyors including the Southern California Water Company.

Actions Planned:

1. CDHS has asked ATSDR to conduct a dose reconstruction exposure investigation of perchlorate exposure in the Cordova System. ATSDR has agreed to come to visit California and investigate the effort that would be needed to conduct the dose reconstruction.

2. CDHS is in the process of submitting a protocol to ATSDR to conduct a health statistics review of the CDHS Genetic Disease Branch data of newborn thyroid testing in relation to doses from the dose reconstruction exposure investigation.

3. The Air Force and the Perchlorate Study Group (a number of manufacturers and users of perchlorate) are sponsoring an investigation into fate and transport questions regarding perchlorate. For instance, they will investigate if is perchlorate is taken up and bioconcentrated by vegetable crops and the skin permeability of perchlorate.

4. The Air Force and the Perchlorate Study Group are also sponsoring a series of animal studies to address some of the information lacking in understanding perchlorate toxicology. CDHS cooperative agreement staff along with other state and federal scientists, were asked by the Air Force to recommend and oversee the planning of the

animal studies. As of August 1997, the study protocols have been finalized and the process of choosing a laboratory to conduct the studies is underway. A report on the studies is expected in mid-summer 1998.

Recommendations for Further Action:

1. Continue communicating with the Cordova System water customers about the perchlorate issue. For instance, send perchlorate fact sheet or some other type of summary in the next mass mailing to the Cordova System well users.

2. Discontinue, as Southern California Water Company has been doing, using wells that have levels of 18 ppb or greater of perchlorate.

3. If indicated based on new toxicological information, review toxicological evaluation of past and current perchlorate exposures in the Sunrise District.

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CERTIFICATION

The Perchlorate Contamination in the Citizens Utilities' Suburban and Security Park Water Service Areas, Aerojet-General Corporation Health Consultation was prepared by the California Department of Health Services under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the health consultation was initiated.

Technical Project Officer, SPS, SSAB, DHAC

The Division of Health Assessment and Consultation, ATSDR, has reviewed this health consultation and concurs with its findings.

Chief, SPS, SSAB, DHAC, ATSDR

Table 1: Cordova System Well Descriptions and Perchlorate Sampling Results

Well	Drawing Depth (ft bgs)	Status of Well	Description of Service Neighborhood	Description of Use	Perchlorate Analysis (ppb)						
					February[b]	March 11/13/18/ 24/25/27[c]	April 9 or 10[c]	May 12/15/13[c]	June 18/19/20[c]	July 9[d]	August 13[a]
1-Alicante	102-306		Commercial	Summer and Fire Flows	<35	< 4.0[a]	ns	< 4.0[a]	< 4.0[a]	< 4.0[a]	< 4.0[a]
2-	[illegible]	Destroyed									
3-Gilbert	152-240		Residential	Summer and Fire Flows	ns	< 4.0[a]	ns	< 4.0[a]	< 4.0[a]	< 4.0[a]	< 4.0[a]
4-El Segundo	102-306		Residential	Summer and Fire Flows	ns	< 4.0[a]	ns	< 4.0[a]	< 4.0[a]	< 4.0[a]	< 4.0[a]
5-Marcel	152-480		Residential	Daily in Summer	ns	< 4.0[a]	ns	< 4.0[a]	< 4.0	ns	< 4.0
6-Dolecetto	152-405		Residential	Daily	ns	< 4.0[a]	ns	< 4.0[a]	< 4.0[a]	< 4.0[a]	< 4.0[a]
7-Georgetown	240-445		Residential	Daily, Continuous Summer	ns	< 4.0[a]	ns	< 4.0[a]	< 4.0	< 4.0	< 4.0[a]
8-Agnes	250-470		Residential	Daily in Summer	ns	< 4.0	ns	< 4.0	< 4.0	< 4.0	< 4.0
9-McGregor	233-460	Off-line- 9/95 Destroyed- 11/97	Residential	Fire Protection only	ns	ns	65	ns	ns	ns	ns
10-Negrara	276-416		Residential	Fire Protection	ns	< 4.0	ns	ns	ns	ns	< 4.0
11-Cristobal	214-468	Off-line 4/8/97 thru 6/19/97	Residential	Daily, Continuous in Summer	ns	4.4	5.1	< 4.0[a]	< 4.0[a]	4.8	4.2
12-Woodcliff	268-556		Residential	Manual On	ns	< 4.0	ns	< 4.0	< 4.0	<4.0	< 4.0
13-Citrus	222-500	Off-line- 2/11/97	Residential	Continuous	220/220*	260	250	250	320	ns	310

Well	Drawing Depth (ft bgs)	Status of Well	Description of Service Neighborhood	Description of Use	Perchlorate Analysis (ppb)						
					February[b]	March 11/13/18/ 24/25/27[c]	April 9 or 10[c]	May 12/15/13[e]	June 18/19/20[c]	July 9[d]	August 13[e]
14-Whistler	236-446	Off-line 4/8/97 thru 6/19/97	Residential	Daily, Continuous in Summer	<35	4.4	4.0	11	8.7	4.8	4.2
15-Folsom Blvd.	237-568	Off-line- 2/11/97	Commercial	Continuous	95/65*	120	120	130	140	120	140
16-Pyrites	195-565	Off-line- 2/11/97	Commercial	Continuous	210/220*	240	250	240	270	260	260
17-Park	89~271		Residential / Park	Daily	ns	< 4.0	ns	< 4.0	< 4.0	ns	< 4.0
18-Mather Field	363-533	Date Drilled - 05/86	Commercial	Daily	ns	< 4.0	ns	< 4.0	< 4.0	< 4.0	< 4.0
19-Kilgour	330-575	Date Drilled - 3/88 Off-line 4/8/97 thru 6/19/97	Commercial	Daily	<35	6.8	7.6	12	< 4.0	11	8.5
20-Coloma	430-590	Date Drilled - 10/92	Commercial	Continuous	ns	ns	< 4.0	< 4.0	< 4.0	< 4.0	< 4.0
21-Gold Country	290-580	Date Drilled - 6/94	Residential	-	<35	< 4.0	ns	< 4.0[a]	< 4.0[a]	< 4.0	< 4.0

*= average of triplicate
ns= not sampled
a= Perchlorate detected at a concentration <4.0 ppb, but not quantitated
b= Data taken from Reference (11)
c=Data taken from Reference (13)
d=Data taken from Reference (14)
e= Data taken from Reference (15)
ft bgs= feet below ground surface

Table 2. Perchlorate Contamination in the Cordova System-Completed Exposure Pathway for Different Receptor Populations

Receptor Group Pathway Name	Source	Environmental medium	Point of Exposure	Route of Exposure	Exposed Population	Time
Residential Exposure in the Cordova System	Aerojet, McDonnell Douglas (?)	Groundwater wells in the Cordova System	Groundwater wells in the Cordova System	Ingestion	Adult Residents	Past Current
Worker exposure in the Cordova System	Aerojet, McDonnell Douglas (?)	Groundwater wells in the Cordova System	Business Tap	Ingestion	Workers	Past Current
Frequent customer or visitor to a business in the Cordova System	Aerojet, McDonnell Douglas (?)	Groundwater wells in the Cordova System	Business Tap	Ingestion	Frequent customer; Frequent visitor	Past Current

Table 3. Exposure Factors for Each Receptor Population of the Completed Exposure Pathway in the Cordova System

Receptor Group Pathway Name	Exposure Parameter	Value
Resident exposure in the Cordova System	Ingestion Rate	2 liters (8.4 cups)/day
	Body Weight	70 kilograms (154 pounds)
	Exposure Frequency	7 days/week 52 weeks/year
	Averaging factor	365 days/year
Worker exposed at a business served by the Cordova System	Ingestion Rate	3.7 liters (15.6 cups)/day
	Body Weight	70 kilograms (154 pounds)
	Exposure Frequency	8 hours/day 5 days/week 50 weeks/year
	Averaging Factor	365 days/year
Frequent customer or visitor to a business in the Cordova System	Ingestion Rate	0.24 liters (1 cup)/visit
	Body Weight	70 kilograms (154 pounds)
	Exposure Frequency	5 visits/week 50 weeks/year
	Averaging Factor	365 days/year

Figure 1
Perchlorate Groundwater Plume in Relation to
Aerojet and Cordova Water System

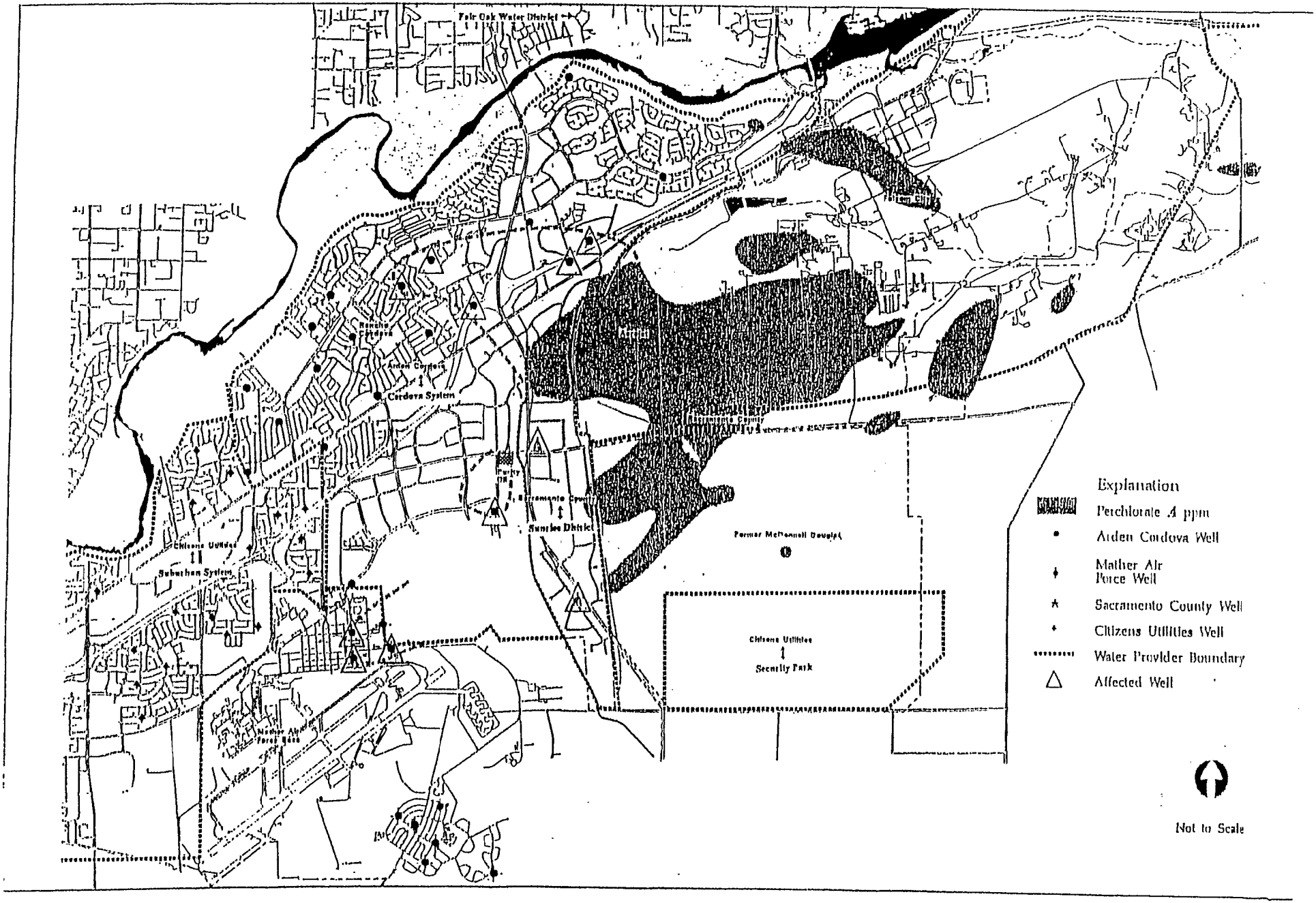
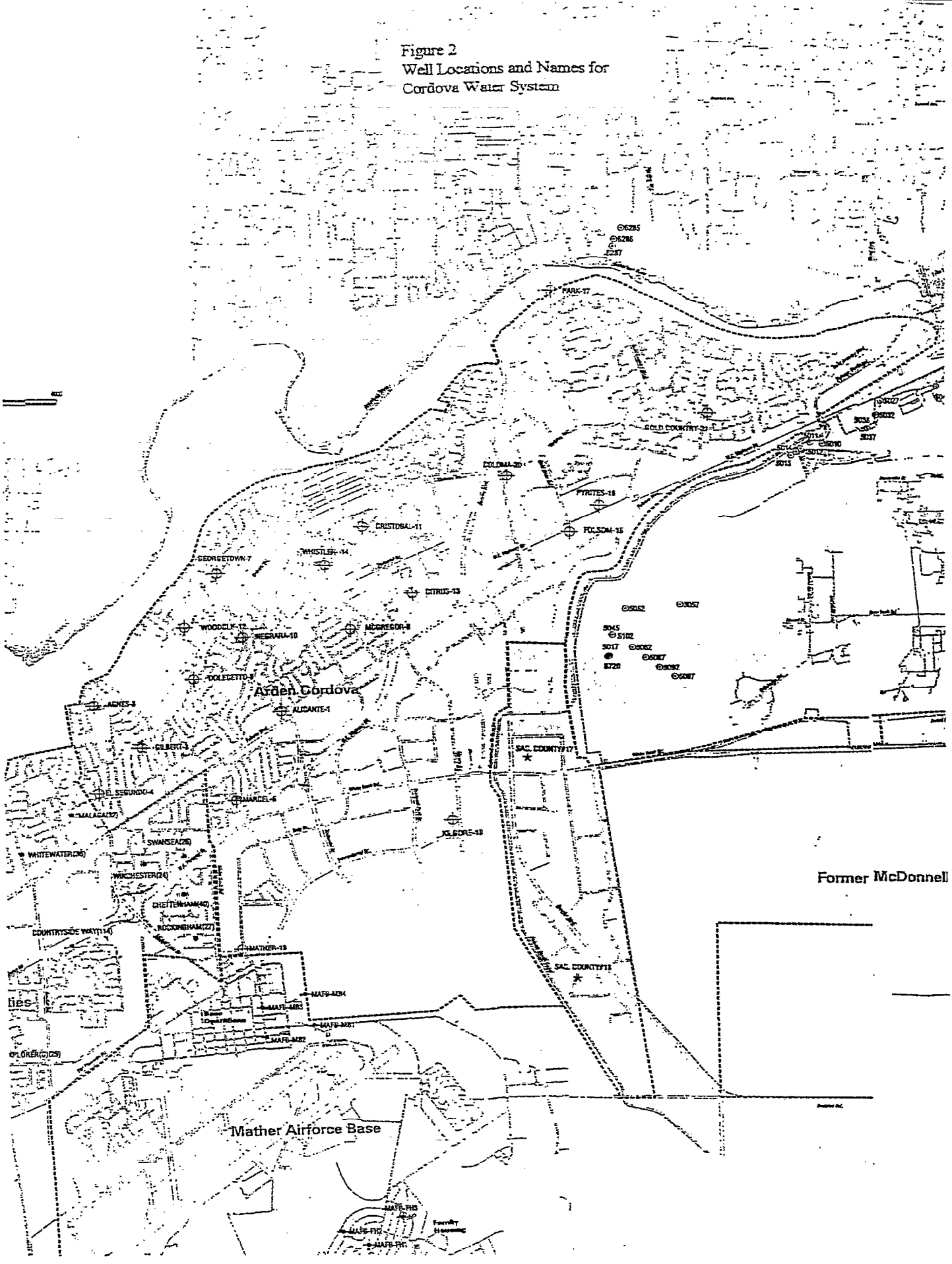


Figure 2
Well Locations and Names for
Cordova Water System



CALIFORNIA DEPARTMENT OF HEALTH SERVICES
DIVISION OF DRINKING WATER AND ENVIRONMENTAL MANAGEMENT

DRINKING WATER PROGRAM

PERCHLORATE IN DRINKING WATER—MAY 1997

BACKGROUND. As a result of cleanup of contaminated shallow groundwater at Aerojet General Corporation's chemical manufacturing and rocket testing facility in eastern Sacramento County near Rancho Cordova, water treated to remove volatile organic chemicals is reinjected into groundwater aquifers in the area. The reinjected water contains up to 8,000 parts per billion (ppb) perchlorate, a chemical component of solid rocket propellant.

Recently, drinking water wells in Rancho Cordova have been found to contain perchlorate. In February 1997, perchlorate in drinking water wells was present in concentrations as high as 65 to 280 ppb. In April 1997, using an improved method developed by the Department of Health Services' (DHS') Sanitation and Radiation Laboratory sensitive to 4 ppb, perchlorate was also found in several other drinking water wells at concentrations as low as 4 to 16 ppb.

The primary human health concern related to perchlorate is that it can interfere with the thyroid glands' ability to utilize iodine to produce thyroid hormones. Because perchlorate has not been a common contaminant, no federal or state drinking water standard exists.

DHS' PROVISIONAL ACTION LEVEL FOR PERCHLORATE. In February 1997, DHS informed drinking water utilities that the US Environmental Protection Agency (US EPA) had evaluated the health effects of perchlorate as part of its Superfund activities. Based on the US EPA evaluation, a drinking water concentration of 4 ppb appeared to be health protective.

Because the levels of perchlorate detected in February 1997 were well above the 4-ppb provisional level and the 35-ppb detection level existing at that time, DHS expressed concern that continued exposure of the public to perchlorate in the water supply might lead to adverse health effects among the users of the water. As a result, DHS advised the utilities to arrange for public notification or alternative sources of water free of perchlorate pollution as soon as possible. The wells contaminated with perchlorate were removed from service.

During subsequent monitoring, the DHS Drinking Water Program, in cooperation with the California Environmental Protection Agency's Office of Environmental Health Hazard Assessment, reviewed the US EPA reports on the risks to human health from exposure to perchlorate. US EPA reported a range of exposures that would be considered to provide adequate health protection, which correspond to a 4-ppb to 18-ppb range of concentrations. As a result of that review, DHS revised its provisional action level from 4 ppb to 18 ppb.

DHS' ADVICE TO DRINKING WATER UTILITIES. Although perchlorate is not a chemical for which a standard exists, DHS has recommended that utilities promptly notify their customers about its presence whenever drinking water is served that contains perchlorate at concentrations greater than 18 ppb. Lower concentrations are not considered to pose a health concern for the public, including children and pregnant women.

In the situation in Rancho Cordova, DHS also encourages information about perchlorate in drinking water to be provided to drinking water customers and workers in the affected area. Given the local concern about the impact of perchlorate on drinking water supplies, DHS believes it is important for people who use the water for drinking and cooking to receive periodic updates, so that they may be informed about the concentrations present as they relate to the provisional action level.

Questions should be directed to DHS' Drinking Water Program at (916) 323-6111.

March 4, 1997

Dear Water Customer;

Arden-Cordova Water Service takes pride in the quality of water that is served to our community and always strives to keep our customers informed of any issues that may potentially affect your service. We continually monitor all of our water supplies for numerous chemical contaminants to ensure that the water served to you meets all State and Federal water quality standards. We often monitor for uncommon constituents that are not regulated but may pose a threat to our water supply according to new scientific studies. Recent analysis of our water supply shows a potential threat from a little known chemical called perchlorate. Perchlorate is an oxidizer that has been used by the aerospace industry in the testing of solid fuel rockets.

Public Health officials have told us that water containing perchlorate can interfere with the thyroid gland's ability to utilize iodine to produce thyroid hormones. As of now, neither the U.S. Environmental Protection Agency (U.S. EPA) nor the California Department of Health Services has established a drinking water standard for perchlorate.

Since the 1980's Aerojet has been treating the groundwater contaminated with Trichloroethlylene (TCE) by pumping from contaminated shallow wells, removing TCE through an air stripping treatment system, and then re-injecting the treated water into the deep portion of the groundwater aquifer. Unfortunately the treatment to remove TCE does not remove perchlorate which is also a contaminant in the shallow wells.

On October 25, 1996, the Central Valley Regional Water Quality Control Board (CVRWQCB) issued a Cleanup and Abatement Order to Aerojet to address the issue of on-site groundwater contamination by perchlorate. The abatement order was issued when the CVRWQCB determined that a plume of groundwater containing a high concentration of perchlorate was moving off-site from Aerojet toward public water supply wells.

As soon as we were notified of the potential threat to the community's water supply we had samples collected from all wells in the area. The results indicated three of our wells showed detectable levels of perchlorate. Because of the uncertainty associated with the health effects of perchlorate, these wells were immediately removed from service. We are continuing to work in cooperation with the Department of Health Services, the CVRWQCB, and the State Department of Toxic Substance Control to eliminate any future impact to our drinking water supply. We are also working diligently on construction of additional water delivery systems to meet the immediate water supply needs of the community.

If you have any questions, we urge you to contact the Arden-Cordova Water Service's Customer Service Superintendent Michael W. Benbow. He can be reached at 916-852-0552. Information is also available on our Web site at SCWC-Region1.com.

On March 18, 1997, at 6:30 p.m., Arden-Cordova Water Service and Sacramento County will be holding a public meeting. The meeting will be located in the Multipurpose Room at Mills Middle School. For address and directions, please refer to the map on the reverse side of this notice.

Attachment C

PERCHLORATE
IN DRINKING WATER

MAY 1997

Perchlorate, a chemical used in the manufacture of rocket fuel, was discovered in five drinking water supply wells west and southwest of the Aerojet property in Rancho Cordova in February, 1997. Since that time, the California Department of Health Services (DHS) has been advising the water service companies in order to ensure that the level of perchlorate in drinking water is well below the amount which could cause a health problem. This fact sheet will explain how perchlorate got in the water, what effects perchlorate can have on your health, and how DHS decides about safe levels of perchlorate in drinking water.

How Did Perchlorate Get in the Drinking Water?

The Aerojet Corporation began manufacturing liquid and solid propellants for rocket systems and assembling and testing the rocket systems in 1951. In 1979, state and federal agencies discovered that perchlorate and a group of chemicals called volatile organic compounds (VOCs) were migrating in the groundwater from the Aerojet site toward the American River. In 1988, Aerojet began removing the shallow groundwater and taking out the VOCs. This treated water was then reinjecting into the deep groundwater at the western edge of the Aerojet property. Since there is currently no treatment for perchlorate, the water that was reinjected still contained perchlorate. The perchlorate-contaminated groundwater has since migrated toward public water supply wells.

State agencies are investigating other potential sources of perchlorate in the area such as the former McDonnell Douglas facility and the Purity Oil Sales facility.

How Was Perchlorate Discovered in the Drinking Water Wells?

Since Aerojet began reinjecting the treated water, they have been required to test for perchlorate in the groundwater on a regular basis to ensure that it has not migrated off the property. In the past, the levels at which Aerojet was able to detect perchlorate in the water were much higher than the levels at which there could be some type of health effect. Recently, Aerojet changed to a method which detects perchlorate at much lower levels. This method indicated that the levels in some of the drinking water wells were of potential public health concern.

How Could Perchlorate Affect My Health?

Perchlorate could interfere with the function of the thyroid. At high levels, perchlorate interferes with the production of thyroid hormones and could result in a below normal level of thyroid hormone in the body. This condition is called hypothyroidism. In some cases, the pituitary gland responds to the low level of hormone by producing thyroid stimulating hormone (TSH). This increase in TSH can cause the thyroid gland to become enlarged. People with hypothyroidism can feel sluggish, depressed, cold, or tired. However, these complaints may not necessarily be related to hypothyroidism but could be caused by many other conditions. Thyroid disorders are very common, and are more frequent in females than in males.

At one time, one form of hyperthyroidism (a condition in which the thyroid produces an *above* normal level of thyroid hormone) was treated with perchlorate because it effectively reduces the production of thyroid hormones. A few patients who were treated with perchlorate developed disorders of the blood or immune system. However, there is not enough information to know if these problems were caused by perchlorate.

Is There a Test to Show If I Have Thyroid Problems?

Yes. There are simple blood tests which can measure the amount of TSH from the pituitary gland and test for the level of thyroid hormone. Most diseases of the thyroid can be treated, so you should contact your physician if you think that you might have a thyroid condition.

What Happens When I Am No Longer Exposed to Perchlorate?

Although this is highly unlikely, if exposure to perchlorate did have an effect on your thyroid, the thyroid would be able to resume its normal functioning shortly after stopping exposure to perchlorate.

Is It Safe to Drink Water with Perchlorate?

Based on studies of perchlorate, the Drinking Water Program of the California Department of Health Services has set levels for perchlorate in drinking water that are protective of your health (18 parts of perchlorate per billion parts of water also known as 18 ppb). Even if you are pregnant or have an infant or a child in your home, it is not harmful to use drinking water from the tap.

Currently, there are studies being conducted which will further clarify the safe level for perchlorate in drinking water. Your water company will keep you informed if the perchlorate gets above the health protective level.

No commercially available water filtering system is able to remove perchlorate, but bottled water can be used as a substitute.

How Did DHS Decide What are the Safe Levels for Perchlorate in Drinking Water?

In 1992 and again in 1995, the US Environmental Protection Agency (USEPA) reviewed all available toxicological data on perchlorate: studies of patients who were being treated medically with perchlorate, and animal studies where rats, mice, or rabbits were given varying amounts of food or water containing perchlorate. The USEPA determined that while there was considerable information about the effects of short-term exposure to perchlorate on the thyroid, there was not enough information about the effects of long-term exposure.

In order to determine a safe level for a given chemical in drinking water, scientists rely on information from health studies. When there is limited information available, scientists include a large margin of safety until there is sufficient information to develop a permanent standard.

DHS set a temporary safe level for perchlorate at 18 ppb. This level includes a 300-fold margin of safety. In other words, this level is 300 times less than the level at which no health effects were observed in prior studies.

In terms of your drinking water consumption:

If your water is reported to contain 250 ppb of perchlorate and you drank 2 liters (8 cups) of that water per day, you would still be taking in an amount of perchlorate that is 20 times lower than the amount at which no health effect was observed. If your water is reported to contain 12 ppb of perchlorate and you drank 2 liters (8 cups) of that water per day, you would still be taking in an amount of perchlorate that is 450 times lower than the amount at which no health effect was observed.

For More Information

For further information about perchlorate in the drinking water and the health effects:

Steve Book, Ph.D.
Drinking Water Program
California Department of Health Services
(916) 323-6111

Marilyn Underwood, Ph.D.
Environmental Health Investigations Branch
California Department of Health Services
(510) 450-3818

For information about thyroid:

The Thyroid Foundation of America
(800) 832-8321

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ARDEN - CORDOVA WATER SERVICE

11088 D OLSON DRIVE • RANCHO CORDOVA, CA 95670 • (916) 852-0552 • FAX (916) 852-6608

Date: April 29, 1997

FOR IMMEDIATE RELEASE

Contact: Michael W. Benbow
(916) 852-0552

Arden-Cordova Water Service (ACWS) is committed to providing the highest water quality to its customers. One of the ways we fulfill this commitment is by continually monitoring the water supply for numerous chemical contaminants. We are committed to keeping the community and customers informed of issues that effect your water service.

On January 9, 1997, the Company was notified that perchlorate contamination of the groundwater was a possibility. In February, when sampling efforts detected levels of perchlorate, the water supply was shut down at three groundwater supply wells.

During the last week of March 1997, the DOHS sampled 40 wells in the Rancho Cordova and Gold River area. The initial test results indicated the presence of very low levels of perchlorate in three additional wells. Although we are still awaiting the confirmation test results, the Company has removed these three wells from service.

The DOHS has worked diligently to enhance the laboratory methods used in the detection of perchlorates and has achieved a detection limit of 4.0 ug/l. (Equivalent to locating four paper clips in 1,000 box cars full of paper clips.) The improvement in the detection ability provides consumers with the secure knowledge that no source of supply containing perchlorate is being used.

Although six (6) wells have been shut down, we are seeking additional water supply to meet the summer demand. Currently, one mile of water main is being installed along Folsom Blvd. In addition, plans are under way to construct a two million gallon reservoir and expand the water treatment facilities.

For answers to health related questions, please call Dave Lancaster, Department of Health Services (916) 229-3143. Please direct all other questions to Michael W. Benbow, Superintendent, Arden-Cordova Water Service.

Additional water quality information can be found on the Company's web site:
scwc-region1.com

Drinking Water Update
to
Arden-Cordova Water Service Customers

In an ongoing effort to honor our commitment to communicate with our customers, we are taking this opportunity to provide you with updated information regarding perchlorate.

On April 29, 1997, we notified you that six groundwater supply wells had been removed from service due to the detection of perchlorate in the water supply. At the time, Department of Health Services' (DHS) provisional action level of 4 ppb was the determining factor, water supply wells that tested at 4 parts per billion (ppb) or lower appeared to be protective of health.

The DHS has recently reevaluated the scientific studies in greater detail and, as a result of these studies, the provisional action level for perchlorate has been raised from 4 ppb to 18 ppb. In other words, levels at 18 ppb or lower are not considered a health concern to the public, including small children and pregnant women.

In accordance with the DHS' revised action level, service has been restored to three of our six wells. With the arrival of summer and hot weather, the three wells will add to our water supply, putting us in a better position to meet the summer demand.

We are committed to maintaining and providing the highest level of water quality, as monitoring of our water supply wells continues. We want to reassure our customers, no source of supply that exceeds the provisional action level of 18 ppb will be released into the distribution system.

Thank you for your support and cooperation throughout this highly sensitive time. Please contact Michael W. Benbow, Superintendent, at (916)852-0552, if you have additional questions.

A perchlorate fact sheet is available at our local office. Please stop by and pick one up, or call if you would like us to mail you one. The fact sheet, as well as additional water quality information, can be found on the Company's web site: scwc-region1.com

APPENDIX A. RESPONSE TO COMMENTS FROM SITE TEAM REVIEW

In 1995, EHIB formed a site team to assist us in identifying public health concerns and to oversee what we do during the health assessment process for the Aerojet General site. The site team is composed of community residents, state and federal environmental and health agency staff, Aerojet staff, as well as EHIB staff. Health consultations that are produced as apart of the health assessment process are released for comment to site team prior to them becoming final. We received comments on this health consultation from the Drinking Water Branch of CDHS, U.S. EPA, DTSC, RWQCB, Aerojet, and a community member. In this appendix, we will respond to the submitted comments.

COMMENTS RECEIVED FROM THE DRINKING WATER BRANCH OF CDHS

The Drinking Water Branch of CDHS regulates water purveyors in the state, and their comments were minor technical corrections to the numbers we cited in the text. These corrections were made to the original document.

COMMENTS RECEIVED FROM A COMMUNITY MEMBER ON THE SITE TEAM:

We received comments with attachments from one community member. It was not possible to add the attachments to the document.

Community member's comment: Page 1, bottom of paragraph 3. Is Purity Oil still a suspect?

CDHS response: We are listing this company as a source being investigated by the regulatory agencies, but we are not aware of the status of the source investigation since we are not a part of this on-going investigation.

Community member's comment: Page 3, 1st paragraph. Mike Benbow and Paul Shubert of ACWS told me in the first week of January, 1997 that Well 9 was shut down on Christmas Eve 1996 and that it was "being destroyed as we speak. " Obviously it wasn't destroyed, since it was sampled at a later date.

CDHS response: In Table 1, we had indicated that well #9 was taken off-line on September 1995. However, even though the well was <u>not</u> being used as a water source for the Cordova System after this date, it was not destroyed (filled with concrete) until November 1997. Thus it was possible to sample the well until fairly recently. When the well was pumped to take a sample, no water from the well was added to the Cordova System.

Community member's comment: Page 4, third paragraph. ACWS was officially aware of potential perchlorate contamination in early January 1997 when they sent a letter to Robert McGarvey of the Rancho Cordova Incorporation Committee. This letter acknowledged information on perchlorate I had given Mike Benbow of ACWS in December.

CDHS response: While Southern California Water Company was made aware of a potential perchlorate problem in January 1997, it was not until February 11, 1997 that they were notified of any well sample results that showed perchlorate to be present in their wells.

Community member's comment: Fourth paragraph. The Sacramento Bee was absent from the March 18, 1997 meeting. People who received highest exposures next to perchlorate from Well 13 are not aware they have been exposed because they are renters.

CDHS response: Comment noted.

Community member's comment: Page 5, third paragraph. See my comments on Perchlorate in Drinking Water, May 1997.

CDHS response: The fact sheet is already finalized and was added to this health consultation as an attachment for reference only. At this time, we are not planning on revising it.

Community member's comment: Page 6, second paragraph. I'm eager to learn more about re-injection in 1984. See my Hypothesis I on distribution of perchlorate in Rancho Cordova.

CDHS response: CDHS appreciates the various hypotheses that have been put forth by the community member and while it is not the place to respond to them here, we will take them into consideration as we continue to work on the site.

Community member's comment: Page 7, third paragraph. What are the relevant chemical similarities of cadmium chloride and perchlorate? Is there any thinking that perchlorate's chaotropy in solution acts in a manner similar to cadmium or mercury?

CDHS response: The most relevant characteristic is that both chloride and perchlorate are anions. According to a highly regarded dermal absorption reference source, the permeability of charged ions is extremely low and membranes appear to be more permeable to cations than anions (42).

Community member's comment: Page 7, fifth paragraph. My concern for nitrate-perchlorate synergy was based on a proposed perchlorate reference level of 400 p.p.b. when the baby bottle model suggested that 500 p.p.b. Apparently there are more sophisticated toxicological concerns about perchlorate at lower concentrations, so nitrate-perchlorate synergy is not an issue for me at this time.

CDHS response: Comment noted.

Community member's comment: Page 8, first paragraph. Are you certain there were only seven fatalities? I'll double-check.

CDHS response: We were quoting a second-hand report in which it was stated that there were seven fatalities; however, since this may not reflect the total number, we revised the text so that we did not have to indicate how many deaths had occurred due to aplastic anemia developing in Graves' patients treated with potassium perchlorate.

Community member's comment: page 8, second paragraph. The physiological differences between children and adults do not make comparison of perchlorate effects between them a two-tailed test -- children being more robust than healthy adults in matters of iodine deficiency is not a possible outcome. Given the need for iodine in infant neurological development, there is no way infants can be more resilient than adults in this regard. Theoretically, the uncertainties should demand a lower reference level of 4 p.p.b. But the twin specters of a consumer scare on Imperial Valley produce and mobs of irate hypochondriacs in Orange County and San Diego dictate the 18 p.p.b. reference limit not be lowered to take children into account until more is known.

CDHS response: Based on this comment and similar comments by others, we have added more information about the importance of the thyroid for a developing child and other information about the physiology of a child that make them more sensitive to insults on the thyroid.

Community member's comment: page 8, third paragraph. I have serious problems with calling an acute half-blocking of thyroid iodide uptake a no-observable-adverse-effect. I'd like to talk about this with Dr. Peter Houser of the U.S. E.P.A.'s Endocrine Disrupter Screening Test Advisory Committee. My idea of thyroid NOAEL is TSH levels below the TSH minimum prompted by thyroid autonomy (i.e. greater sensitivity to TSH by the thyroid).

CDHS response: Comment noted.

Community member's comment: Page 9, first paragraph. How about perchlorate inducing hypothyroidism that leads to preferential absorption of carcinogenic I-131? See Hypothesis I, Test B.

CDHS response: We consulted with thyroid experts about this comment, and no one was aware of any evidence that suggested a person with hypothyroidism would preferentially absorb or incorporate radioactive iodine into the thyroid or thyroid hormone. We are also unaware of the Rancho Cordova area being affected by releases from Rancho Seco, and whether there were any releases of I-131 in particular.

Community member's comment: Page 9, fourth paragraph. See comment on page 8, second paragraph.

CDHS response: See previous response to similar comment.

Community member's comment: Page 10, first paragraph. I do not agree with the conclusion "it is unlikely that the residential exposure to well #13 did cause any non-cancer health effects."

CDHS response: Comment noted.

Community member's comment: Page 12, second paragraph. Exposure as early as 1987, see Hypothesis 1.

CDHS appreciates the various hypotheses that have been put forth by the community member and while it is not the place to respond to them here, we will take them into consideration as we continue to work on the site.

Community member's comment: Page 13, second paragraph. I'm not sure about the conclusion of safety below 18 p.p.b. Until more is known, I now avoid my tap water.

CDHS response: Comment noted.

Community member's comment: Page 13, eighth paragraph, Planned Action 2, Genetic Disease Branch data - while you're checking thyroid problems, you might look into the Angelman's syndrome variant that involves a break in chromosome 15. Grandmother from Well 13 area reports her daughter and two of her friends from Cordova High have children with this malady.

CDHS response: The Genetic Disease Branch does not collect information about Angelman's syndrome and we have no reason to suspect, based on chemical characteristics or toxicological mechanism, that perchlorate exposure would cause chromosomal abnormalities.

Community member's comment: Page 14, first paragraph. Will Food and Drug Administration be involved with Perchlorate Group's bioconcentration study?

CDHS response: We can not answer for the Air Force or the Perchlorate Study Group, but we are not aware that the U.S. Food and Drug Administration is involved in the perchlorate studies.

Community member's comment: Page 14, second paragraph. I heard first report in April.

CDHS response: Comment noted.

Community member's comment: Recommendations for further action: Revise Fact sheet? Poll local endocrinologists and map ratio of their toxic nodular goiter/graves disease cases by zip code? See Baltisberger, Minder, and Burgi's "Decrease of incidence of toxic nodular goiter in a region of Switzerland after full correction of mild iodine deficiency" in the European Journal of Endocrinology 1995, 132: 546-549.

CDHS response: We are willing to issue another fact sheet that deals with the perchlorate issue when there is new information that would make another fact sheet needed, at this time we do not

believe this is needed. We have looked into goiter as a possible health outcome, but at this time we are going to focus our efforts on studying newborn thyroid function.

COMMENTS RECEIVED FROM THE U.S ENVIRONMENTAL PROTECTION AGENCY

The EPA offers the following comments for your consideration:

USEPA comment: Page 7 - fourth sentence - the statement that "ammonium perchlorate has relevant physical and chemical characteristics similar to cadmium chloride does not appear to be justified. Although both of these compounds are salts, on dissolution (a necessary step in absorption) perchlorate would become an anion (negative charge) and cadmium would become a cation (positive charge). Therefore, one could conclude on this basis alone that cadmium would not be an appropriate surrogate for perchlorate. Comment applies to all reports but Fair Oaks Water District Report.

CDHS response: According to a highly regarded dermal absorption reference source, the permeability of charged ions is extremely low and membranes appear to be more permeable to cations than anions (42). *Thus, the comparison of perchlorate should not be made between the cation, cadmium, but the anion, chloride, that is found when cadmium chloride is in solution.*

USEPA comment: Page 8 - third paragraph - NOAEL term use - The NOAEL is an experimentally derived value that is often used as a basis for the RfD, however, the NOAEL is not regarded by EPA as a value that "would not be expected to be associated with any adverse effect". Rather, this definition better fits the RfD that is derived from a NOAEL after considering uncertainties in the database. Comment applies to all reports but Fair Oaks Water District Report.

CDHS response: We have corrected the use of NOAEL and RfD in the text.

USEPA comment: Page 11 - last paragraph - Suggest changing the text from "noncancer (thyroid depression) health effects would not have occurred . . ." to" would not be expected".

CDHS response: We preferred the original wording, so no changes have been made to the text.

USEPA comment: Page 23 -Table 3 - Worker exposure - The tap water ingestion rate for workers is listed as (3.7 liters/day) which is almost twice the assumption that is used for a residential scenario. Should this be 0.37? This applies to Mather Air Force Base Water Service Area Report Table 3 - page 21 and the Sunrise District of the Sacramento County Water Service Report Table 2 - page 18. Also, the Citizens Utilities' Suburban & Security Park Water Service Areas Report Table 3 - page 19 lists worker exposure at 2.0 liters/day should this be 0.37?

CDHS response: We are using a reference from USEPA document entitled "Exposure Factors

Handbook", published in 1989. In this document, the total fluid intake for a moderately active man is cited as being 3.7 liters/day. This document cites the Report of the Task Group on Reference Man from the International Commission on Radiological Protection, published in 1981 for this number. This higher intake of water does seem appropriate given the labor-intensive commercial businesses that are located near the perchlorate-contaminated wells.

USEPA comment: Figure 1 - Is it possible to make the Cordova System standout? Found figure hard to use.

CDHS response: Unfortunately, this figure is copied from a hard copy and is not electronically produced, so it is probably not possible to improve upon the quality.

COMMENTS RECEIVED FROM THE CALIFORNIA DEPARTMENT OF TOXIC SUBSTANCES CONTROL

Below are DTSC's comments which may be considered as the documents are finalized.

DTSC comment: In the "Exposure Pathways" sections of the Arden Cordova, Mather Air Force Base and the Sacramento County water district consultations, it is stated that Aerojet began reinjecting water from their treatment plants on the west boundary of the site in 1984 and 1985. The assumption is then made that it took "a couple of years for the perchlorate to move from the reinjection wells" to the water district's wells. An accurate assessment of when the perchlorate contamination occurred and the location of the source of the perchlorate cannot be made without further information and analysis. The reinjection field may not be the source of the perchlorate contamination in many of the affected wells. Aerojet is currently investigating the extent of the perchlorate contamination to the west of its facility pursuant to an order from the Regional Water Quality Control Board. A technical memorandum documenting the results of that investigation is currently scheduled to be submitted in May of 1998, with an Engineering Evaluation/Cost Analysis of remedial alternatives to be submitted in October of 1999. Additional investigations of groundwater to the west of the Inactive Rancho Cordova Test Site (IRCTS), the likely source of perchlorate in several of the affected wells, are also proceeding. DTSC's Project Manager for the IRCTS is Mr. Marvin Woods who can be reached at (916) 255-3666.

CDHS response: EHIB recognizes that a good analysis of the perchlorate migration which would allow us to know when the perchlorate reached the public drinking water supply well, has not yet been done. In fact, we start off the first paragraph in the "Exposure Pathways" section by saying, "It is not clear when the perchlorate contamination reached the Cordova System wells...". However, since the reinjection of treated water is at least one source of the perchlorate found in some of the drinking water supply wells, we found it was important to share information about this source with the reader. We look forward to reviewing the reports that DTSC is referring to, and hope that they will give a more accurate picture of past well contamination levels.

DTSC comment: In the third paragraph of the consultations, it is stated that the Regional Water

Quality Control Board is the lead regulatory agency. While this is correct for some aspects of the project, the lead regulatory agency controlling water district activities is the Department of Health Services, Office of Drinking Water. For matters concerning the Aerojet Superfund Site, the United States Environmental Protection Agency is the lead federal regulatory agency. A co-lead situation exists for certain matters covered under the Aerojet Superfund Site Partial consent Decree (United States District Court, Eastern District of California, Civil Action Nos. CIVS-86-0063-EJG and CIVS-86-0064-EJG).

CDHS response: Being a part of the complex government oversight at this site, we appreciate the clarification to the agency responsibilities. We have tried to rectify this in the text.

COMMENTS RECEIVED FROM AEROJET GENERAL CORPORATION:

Aerojet's comment about the attribution of source of the perchlorate in public water supply wells: Each draft Health Consultation assumes that perchlorate being found in public water supply wells came from the Aerojet Operating Plant, specifically from the reinjection wells associated with the GET facilities. There are numerous locations where such references appear. (See, for example, Arden Cordova Health Consultation at:

Page 6, paragraph 2 and page 22, Table 2.) This assumption is used to project length of exposure and concentrations in the wells over time. The conclusion is made for each well, for every water purveyor, regardless of the well's location, chemical concentrations or differing hydrogeological conditions.

We are aware of no detailed evaluation of sources, groundwater conditions and groundwater and contaminant movement undertaken by DHS or any other agency that would support statements in the DHS Consultations that attempt to link perchlorate in a well to an upgradient source, and it does not appear necessary for DHS to ascribe a source to reach its conclusions. The Health Consultations should identify that potential sources of perchlorate include the Aerojet Operating Plant, Purity Oil site, and the McDonnell Douglas (MDC) Site. DHS should not assert that the only source of the perchlorate is the GET facility recharge wells on the Aerojet Operating Plant. Neither should the period of operation of the GET wells form the basis for assumptions of exposure of potential receptors. As the Health Consultations discuss potential sources, it should discuss the various uses of perchlorate, other than in rocket motor manufacturing, such as the use of perchlorate in pyrotechnics (fireworks), explosives and other industrial activities. It should also note that perchloric acid, which is used in various industrial activities, including metal-plating, in laboratories, and in other operations, when released can result in the formation of perchlorate and its movement into soils and groundwater.

Aerojet believes that there have been no health impacts associated with any exposure to perchlorate in the water supply. If the Health Consultations seek to discuss long term impact by assuming exposure for some period (e.g., 10 years), they can do so without assigning a source, but simply by

positing the potential for such exposure (without reference to a source) and developing an exposure assessment.

CDHS response: These health consultations are written as a part of CDHS's public health review of the impact of the Aerojet General site. Thus, the documents are written in respect to Aerojet General and not to other sites or facilities. We do recognize that perchlorate may have also gotten into the groundwater from sources other than Aerojet and that is why in last sentence of the third paragraph on page 1, we refer to the RWQCB's investigation of "other sources of the perchlorate such as the McDonnell Douglas (now Boeing) and Purity Oil Sales sites."

Aerojet's comment about the toxicology: Aerojet recommends modifications to the discussion on toxicology. We are concerned that the draft consultations do not provide sufficient information about what is known about perchlorate toxicity (thyroid function) and end up, unintentionally, providing a less balanced presentation of the potential for impact and risk. For example, we believe there should be more discussion related to the past use of perchlorate in the treatment of Graves patients and its current use in Europe at very high doses without ill effects. Similarly, we recommend the inclusion of a statement that the mechanism of perchlorate on the thyroid as well as basic thyroid functions are well understood and we believe that the discussion as to exposure associated with children may lead to unnecessary concern and should be changed. Finally, we believe that there ought to be mention of the ongoing studies being conducted at the direction of the Air Force.

CDHS response: We did provide more information in the toxicology section. For instance, we have added more information about past and current uses of perchlorate and what is known and not known about toxicity to the developing fetus and young child. We did have a reference in the recommendations section about the on-going studies by the Air Force and the Perchlorate Study Group and we have added a sentence in the toxicology section referring the reader to the recommendations section for more information about these studies.

Aerojet's comment about the water system operations: The draft Health Consultations, especially in the background sections, contain statements of fact as to the manner of well and system operation of each water entity over time, including detail on well construction and operation in tables. Aerojet has not had an opportunity to complete an evaluation of the accuracy of such statements. We further note that the factual statements generally do not seem to impact the exposure assessment, as the exposure assessment is based upon an assumed concentration that is not generally associated with the specifics of well interties or well operation. We would recommend the Health Consultations state that the water system information is based on current understanding unless DHS has had the opportunity to perform a detailed evaluation of the information.

CDHS response: In each health consultation, we cite the CDHS reports or other reports from which we gained this information. We refer Aerojet to those documents if Aerojet would like to evaluate the accuracy of such statements. We do think it is important to describe for the reader the basic structure of a particular water system; on the other hand, we don't want to add more

information then is necessary. We hope that the amount of information we have provided will allow a Cordova System customer to more easily understand that only some of the water wells in the system have been contaminated with perchlorate. By describing the water system information in this document, it also helps us to decide where we might consider follow-up activities, like an exposure dose reconstruction.

Aerojet's comment about the Exposure Conclusions: The draft Health Consultations are based upon a set of assumptions, including assumed receptors, exposure rates, and concentrations. From these assumptions, an assumed dose is calculated and then compared to the provisional RfD. We believe that the Health Consultations should carefully describe each assumption upon which the Health Consultations were based, and clarify that these assumptions have not been fully evaluated. For example, a preliminary assessment of proximity to a well is used to determine the type of "receptor" (e.g., resident, worker), but the exposure does not assume any dilution of water from that well with water from any other well.

CDHS response: All of the exposure parameters are listed in the table and a Cordova System user can look at these exposure parameters and apply them to their own situation. Thus it does not seem necessary to explain distributions of exposure parameters or in any other way describe each assumption. As for the concentration of perchlorate used in the calculations, in talking with Cordova System staff, they have explained that a person living next to a well may receive 100% water from that source. Thus it does seem proper to use this concentration in a dose calculation.

With these general comments identified, we now progress to the specifics. We use the Arden Cordova Health Consultation as the template for our comments, and emphasize that typically the same issue exists in the other draft Health Consultations.

Aerojet's comment: Page 1, Paragraph 2 and Throughout: The term "perchlorate contamination" is subject to misinterpretation and references should be to "water containing perchlorate" or like phrase.

CDHS's response: In Webster's New Collegiate Dictionary, it says "contaminate" means "to make impure or unclean". Perchlorate is not typically found in groundwater, as would be the case with certain chemicals like arsenic or sulfates which are naturally occurring in groundwater. Thus it does seem appropriate to describe the "contamination" of groundwater by a chemical such as perchlorate. Likewise, it may be appropriate to describe "water containing arsenic" if you are describing water which contains unusually high levels of arsenic due to natural reasons and arsenic-contaminated water if higher levels than normal may be due to non-natural reasons.

Aerojet's comment: Page 1, Paragraph 3: The description of Aerojet operations and Cordova operations has been taken from earlier documents. Aerojet has historically pointed out the inaccuracies in the statements and rather than do so again we recommend, at a minimum, elimination of a reference to Cordova Chemical Company, because we do not believe it used perchlorate. We also recommend an elimination of the reference to the deep injection wells,

because they are not relevant to the issue and can result in confusion when there is later discussion about recharge or reinjection wells associated with the GET facilities, which are different wells.

CDHS response: In the background paragraph, we are describing the lay of the land regarding the general site issues and thus we did not directly suggest that Cordova Chemical did use perchlorate, but rather this company was a part of the history of the site. Since perchlorate is reinjected at the site boundary as a part of the GET operations, we do not agree that reference to these should be eliminated.

Aerojet's comment: Page 1, Paragraph 3: Delete "property" after "Aerojet's."

CDHS response: This incorrect grammar has been corrected in the text.

Aerojet's comment: Page 1, Paragraph 3: Aerojet is not reinjecting treated water at the site's northern boundary.

CDHS response: This has been changed in the text.

Aerojet's comment: Page 1, Paragraph 3: The Regional Water Quality Control Board (RB) is not the lead Agency; DTSC, USEPA and RB together provide oversight pursuant to the Partial Consent Decree.

CDHS response: The description of the lead agency/agencies was changed in the text.

Aerojet's comment: Page 1, Paragraph 4: Southern California Water Company is an "investor owned" company. We believe it to be subject to regulation as a public utility.

CDHS response: Southern California Water Company staff reviewed an earlier draft of the health consultation and this sentence reflects changes that were made based on their comment. Thus, it seems that it would be inappropriate to change this based on Aerojet comments.

Aerojet's comment: Page 2, Paragraph 1: **DELETE COMMENT**. Aerojet suggests replacement of the phrase: "it is unlikely that it will ever be affected" with, "and no perchlorate contamination has been detected."

CDHS response: We have not seen any data that would suggest "and no perchlorate contamination has been detected" in the Arden System; however, we don't believe based on the data that has been collected that "it is unlikely that it will ever be affected". Thus, the text was not changed.

Aerojet comment: Page 3, Continuing Paragraph: Aerojet installed carbon treatment on Well #1 6 in February of 1985.

CDHS response: We revised the text to reflect this comment.

Aerojet comment: Page 3, Paragraph 1: The discussion as to detection of perchlorate ought to be rewritten. Prior to the summer of 1996, Aerojet's laboratory used an ion specific electrode method. In 1997 Aerojet's laboratory did not use a different analytical method for perchlorate analysis to obtain the detection limit of 35 ppb but rather refined or improved the sensitivity of the existing ion chromatography method. In addition, it is accurate to say the "method" detection limit.

CDHS response: Based on this comment and a similar comment by other reviewers, the description of the analytical method was revised in the text.

Aerojet comment: Page 4, Continuing Paragraph: There is no Appendix A.

CDHS response: This was corrected to "Attachment A".

Aerojet comment: Page 4, Paragraph 2: Reference should be to 1997, not 1977.

CDHS response: This was corrected in the text.

Aerojet comment: Page 4, Paragraph 3: The manner in which the audience was asked to respond, the lack of any information as to what each person who responded intended, and the differences in views as to the percentage of persons responding, makes the reference to the hand raising event questionable in a Health Consultation. We suggest it be deleted. If reference is made, it should point out that the reference is made to indicate potential community concern, not that a health problem exists that is associated with perchlorate. Further, the number of people at the March 1997 meeting who raised their hands to respond to an inquiry about a thyroid problem were not tallied. It would be more correct to say "a number of people in the audience responded."

CDHS response: Based on another reviewer's comment this statement was revised in the text to state "significant", rather than 80%, but we do not agree that it should be deleted, as it relates to the health concerns of the community that were expressed at a public meeting.

Aerojet comment: Page 4, Paragraph 4: The letters sent by Aerojet invited attendance to the April meeting.

CDHS response: We revised the text to reflect this comment.

Aerojet comment: Page 5, Paragraph 1: The discussion of the Regional Board's response to questions on continuing injection might lead to a misunderstanding. The Regional Board stated that it was important for Aerojet to continue extraction, treatment and recharge to control the migration of TCE and other volatile organic chemicals (VOCs). The Regional Board staff also stated that continued reinjection of the perchlorate containing water from the VOC treatment system would not affect the movement of perchlorate containing water off-site in the near future.

CDHS response: Since RWQCB did not comment on this, and we think that the description in the text essentially states the same thing as has been commented here, no changes to the text has been made.

Aerojet comment: Page 3, Paragraph 3: We believe it would be appropriate to note that it was Aerojet that notified the water purveyors of perchlorate levels in their wells.

CDHS response: We confirmed this comment with Southern California Water Company and then corrected the text.

Aerojet comment: Page 6, Paragraph 1: See the discussion above regarding the history of perchlorate sampling. It is not accurate to say that the analytical method Aerojet had been using was not sensitive to adequately assess the migration of perchlorate. It would be more accurate to state that Aerojet's historical analytical method's practical quantitation limit (PQL) for perchlorate was 400 ppb. As stated previously, there was no "alternative analytical method" used but the existing method was refined or improved and the PQL lowered.

CDHS response: According to the third sentence of the comment, the older method was indeed not sensitive enough to detect the perchlorate contamination. We did, however, revise the text to reflect the last two sentences of the comment.

Aerojet comment: Page 6, Paragraph 2 and following: This paragraph, as well as others below which need not be separately itemized, make an assumption about source and length of exposure which is not presently supportable. See discussion in general comments.

CDHS response: We realize that historical monitoring of the drinking water wells at low enough detection limits and thus we do not have a good understanding of the migration of perchlorate and past exposures to the Cordova System customers. We also realize that we have not yet seen any attempts to model the movement of perchlorate based on groundwater flow patterns and perchlorate levels in monitoring wells. Thus in trying to review the past exposures, we are left to make the best assumptions possible.

Aerojet comment: Page 6, Paragraph 5: See the comments above as to statements regarding water purveyor and system operation. We note that an assumption is made that geographical proximity to the well is the sole determinant for exposure of a receptor to a particular well. This may be a reasonable assumption for the Health Consultation being undertaken, but we are not aware of a detailed evaluation confirming the accuracy of the assumption and it should be stated as an assumption.

CDHS response: In talking with Cordova System staff, they have explained that a person living next to a well (or intertie) may receive 100% water from that source and we have added a statement in the Background Section that more clearly describes this point. Thus it does seem proper to use concentration of perchlorate measured in an individual well for dose calculation

purposes; however, since this exposure dose may not reflect exposures to other Cordova System customers who live farther away from the affected wells, we have added a statement about this in the Exposure Pathways Section.

Aerojet comment: Page 8, Continuing Paragraph and following: We refer you to the general comments on toxicology above. The draft Health Consultations would be better balanced if there was more discussion related to the use of perchlorate in the treatment of Graves patients and its current use in Europe at very high doses without ill effects. A strong statement that stresses how unlikely it would be to suffer any of these side effects at the levels addressed in the health consultation would be appropriate. In particular, the draft Health Consultations ought to point out that perchlorate has been used successfully and without incident in a fairly large patient population and with a very small number of reports of aplastic anemia even at the very high therapeutic concentrations A statement that the mechanism of perchlorate on the thyroid as well as basic thyroid functions are well understood would help to clarify the presentation. While the provisional RfD is stated as a level in drinking water at 18 ppb, the remaining levels discussed in the document are stated in terms of mg/kg/day. A direct comparison of those doses with the LOAEL/NOAEL and the provisional RfD in the same unit of PPB's would be very useful to give perspective to the dose issue.

CDHS response: As noted on the response to a General Comment from Aerojet, we did provide more information in the toxicology section. For instance, we have added more information about past and current pharmacological uses of perchlorate and what is known and not known about toxicity to the developing fetus and child. We also added a statement in the toxicological section that equates the dose to the drinking water concentrations.

Aerojet comment: Page 8, Continuing and Paragraph 1: The discussion of animal studies should be modified. There are animal studies where toxicologists have interpreted a NOAEL [(e.g. Mannisto (1970) and Caldwell (1996)]. As to the reference to children, in two places there is a discussion that suggests that nothing can be said about children. Aerojet is concerned that the reference might leave the reader with the impression that toxicologists do not consider impact to the thyroid as the focus of the evaluation or it might cause the reader to think that toxicologists view the child's thyroid as not understood. It would be more accurate to state that the mechanism of perchlorate intake on the thyroid is understood and that in evaluating the dose, one must evaluate the possibility that the child may have less iodine reserve which must be considered in evaluating how the child's thyroid compensates in comparison to an adult thyroid. However, any reference should also include the fact that all new-borns are routinely tested for thyroid hormone. levels. Aerojet believes that it would be inappropriate for the Health Consultations to be construed as indicating that children are at risk at the provisional RFD or that exposure to the higher concentrations before well shut down would be associated with any health impact.

While it appears in the text, we believe there should be a clear reference both in the toxicology discussion and in the exposure section, that perchlorate is discharged from the body very quickly and that one would not expect to see any continuing impact on the thyroid once the exposure ends.

CDHS response: See response to previous comment.

Aerojet comment: Page 8, Paragraph 3: Regarding the discussion of safety factors, various toxicologists believe that the hypothyroid individual would not be a sensitive subpopulation. Also, the Health Consultations should recognize that the sensitive subpopulation factor is already being accounted for with respect to DHS comments on exposure of children.

CDHS response: Comment noted.

Aerojet comment: Page 9, Paragraph 2: We recommend that the parenthetical, which describes the concentrations used, be taken out of the parenthetical. It is important that DHS clearly state its assumptions.

CDHS response: We agree and have done so in the text.

Aerojet comment: Page 9, Paragraph 3: See discussion above on children. We believe that the two locations of discussion on children should be combined in one location.

CDHS response: See previous responses.

Aerojet comment: Page 9, Paragraph 4: Exposure discussion includes the volume of tap water consumed per day in liters and perhaps the inclusion of a unit like the number of 8 oz. glasses per day would benefit the average reader, or public citizen. This could be included in the text and in the Table.

CDHS response: We have added this information to the text and table.

Aerojet comment: Page 9, Paragraph 4 and following: While the Health Consultations do note the potential for mixing of water from various sources within the water distribution system, they assume that the person exposed was exposed at the level reported for the well on the date closest to well closure. The Health Consultations should explain that the evaluation uses the assumed concentration at a well to assess impact of a receptor using the well, even though further evaluation may show that mixing and blending of water during water distribution potentially could occur and reduce the estimated level of exposure.

CDHS response: See previous responses to similar comments.

Aerojet comment: Page 9, Paragraph 4 and Following: There is the repeated statement that the estimated doses for [identified type of exposure] from well # [identified well number] exceeded the provisional RfD range and a conclusion stating "health effects may have occurred." The phrase "may have occurred" could be misinterpreted as it may suggest a higher level of risk than existed, given the low levels of perchlorate found in relation to the provisional NOAEL described. Given the uncertainty factors associated with the provisional RfD, Aerojet believes that it would be more

appropriate for the Consultations simply to conclude that the level was over the RFD and then follow with a conclusion as to the unlikely nature of any health impact. If DHS does continue to want to use "may have occurred" language, then the "may have occurred" language should be clarified when presented by referring to the key assumptions, the exposure assessment, etc., (e.g., the number of 8 ounce glasses of tap water needed to be consumed). The health consultations should also stress that there is a significant range between the provisional RfD of 18 ppb and the NOAEL level translated to 4900 ppb (assuming a NOAEL of .1 4 mg/kg/day and a 70 kilogram male drinking 2 liters per day). It would also be useful either to change the reference of "uncertainty" factors to "safety" factors or use the term uncertainty (safety) factors" for the benefit of the reader.

CDHS response: Comment noted.

Aerojet comment: Page 12, Paragraph 2: See the above comments regarding speculation as to source.

CDHS response: See previous response to similar comments.

Aerojet comment: Page 12, Paragraph 4: There are a number of paragraphs that repeat statements made in the exposure section. See discussion above (page 9) relative to language about dose above the RfD. Aerojet does not believe that it is appropriate to conclude that there "may" have been a "health hazard." If language as to hazard is described, it should not be separated from the DHS assumptions about exposure nor should it be stated without the conclusion as to the unlikeliness of any impact. Aerojet further notes that the various Consultations do not always use the same language on "health hazard," and the differences in language do not appear justified (e.g., see Mather page 12 paragraph 3).

CDHS response: Comment noted.

Aerojet comment: Page 13, Bullets #1 and 2 (Actions Planned): Aerojet believes that any dose reconstruction investigation should await completion of further investigations and should not assume sources. See general discussion above.

CDHS response: Comment noted.

Aerojet comment: Aerojet believes that any health statistics review of newborn thyroid testing raises significant issues regarding appropriate protocols for such study, timing of such study in light of ongoing animal studies, appropriateness of such a study in Sacramento and presumes confidence in the "dose reconstruction" exposure assessments. Aerojet requests the opportunity to review draft DHS protocols for any such study.

CDHS response: We will try to include an outside review of the study protocol.

Aerojet comment: Page 13, Bullet #3 and Page 14, Bullet #4: The reference should be to the Perchlorate Study Group, not Perchlorate Work Group.

CDHS response: This has been corrected in the text.

Aerojet comment: Page 14, Bullet #2: The use of the word "safe" is inappropriate, Reference should be to the provisional RfD.

CDHS response: We have modified the text so as to remove the word "safe".

Aerojet comment: References, No. 17. The citation to the authors should be corrected.

CDHS response: This citation has been corrected.

Aerojet comment on Table 1: We have not had adequate opportunity to evaluate the descriptions of all of the wells and the well system. We note that the comments in the Table are based upon assumptions made as discussed in the text and our comments apply.

CDHS response: Comment noted.

Aerojet comment on Table 2: We believe a "source" category for this Table is inappropriate. Please see general comment above on sources.

CDHS response: Comment noted.

Aerojet comment on Figures 1 and 2: The figures are illegible at this size and difficult for the reader to understand. The figures that present chemical distributions were draft figures and were not prepared for the purpose being used and are not reflective of present understanding of groundwater conditions.

CDHS response: We apologize for the quality of the figures. They are only meant to give the reader a basic layout of the perchlorate flow and the well locations and hopefully, this information is still conveyed with these poor quality figures.

COMMENTS FROM THE CENTRAL VALLEY REGIONAL WATER QUALITY CONTROL BOARD

Regional Board staffs comments on the documents are supplied below.

RWQCB General Comment: We recommend that the use of the term "contaminated" be selectively used. Contaminated should be used when the water represents a hazard to the public health. In the case of perchlorate, "contaminated" should not be used when discussing concentrations less than 18

ppb. It is even unclear whether the term should be applied to those concentrations that are currently found in some of the groundwater supply wells (up to 300 ppb). Instead of saying "perchlorate-contaminated water", we would recommend saying "water containing perchlorate".

CDHS response: As was stated under a similar comment raised by Aerojet, in Webster's New Collegiate Dictionary, it says "contaminate" means "to make impure or unclean". Perchlorate is not typically found in groundwater, as would be the case with certain chemicals like arsenic or sulfates which are naturally occurring in groundwater. Thus it does seem appropriate to describe the "contamination" of groundwater by a chemical such as perchlorate. Likewise, it may be appropriate to describe "water containing arsenic" if you are describing water which contains unusually high levels of arsenic due to natural reasons and arsenic-contaminated water if higher levels than normal may be due to non-natural reasons.

RWQCB General Comment: There is a paragraph in each of the health consultations which discusses the "reporting level to the RWQCB" of 400 ppb and a change in method which allowed for a detection level of 35 ppb. In the early 1990's, up until around 1995/96, Aerojet was using a ionspecific electrode to measure perchlorate concentrations in water with a detection level of 400-500 ppb. Aerojet then developed an alternate method using a GC which provided a detection level of 35 ppb and a reporting level of 400 ppb. This method was then used by Aerojet in all work required under the Partial-Consent Decree. In early 1996 RWQCB staff requested Aerojet to report all concentrations between the detection level (35 ppb) and reporting level (400 ppb) as trace. Aerojet was then able to lower their PQL to 100 ppb, while maintaining their detection level at 35 ppb. No method changes were made to get to the lower reporting level. It was in February 1996 that the concentrations in the off-site water supply wells were first reported.

CDHS response: Based on this comment and comments by others, the text was revised.

RWQCB General Comment: When discussing the nitrate levels, make sure that the values reported are designated as milligrams per liter as nitrate, or milligrams per liter as nitrogen. The MCL for nitrate should be expressed in the same units. There are two values for the MCL used in the five health consultations, 20 and 45 mg/l. A single value for the MCL should be used.

CDHS response: We have corrected this in the text.

RWQCB General Comment: We will not supply comments on the toxicological issues presented in the documents. We will rely on the experts at the Department of Health Services to make those evaluations.

CDHS response: Comment noted.

RWQCB comment: Page 2, paragraph 5. The value for the MCL for nitrate should be supplied to allow the reader to determine the significance of the values presented.

CDHS response: We have added the MCL as a reference in the text.

RWQCB comment: Page 4, paragraph 4. The last sentence refers to "80% of the audience responded". We do not recall that a positive response was so high. We recommend not specifying a percentage, but instead saying that a significant number of the audience responded positively, or something similar.

CDHS response: Per this comment, we have revised this statement in the text.

RWQCB comment: Page 6, paragraph 2. There is quite a bit of supposition in the statement that "perchlorate was probably a contaminant in the Cordova System wells since 1987". GET E started injecting in 1985 and GET F did not start injecting until late 1988. Without historical data, it is a stretch to provide a specific date. If the 1987 date remains the uncertainties and assumptions used in deriving that date should be supplied. This comment also applies to the second paragraph of page 12.

CDHS response: We look forward to the RWQCB or other agencies supplying us with better historical information about the historical movement of perchlorate; in the absence of this, we have clearly stated our guesses as to when perchlorate contamination may have affected drinking water wells.

RWQCB comment: Page 9, last paragraph. Though it is discussed in subsequent paragraphs on page 10, we would recommend that since this paragraph talks about exposures with Well No, 13 online, that the exposures be referred to as past exposures.

CDHS response: Given the structure of the health consultation, it seems that the description of the time frame of exposure from well #13 is appropriately addressed two paragraphs later.

RWQCB comment: Page 10, paragraph 3. Are Well Nos. 11 and 14 used as main production wells or are they on stand-by and respond to low pressure system demands? This would change the potential concentrations in the water in the distribution system in the vicinity of the wells.

CDHS response: The proposed dose reconstruction will more accurately explore this comment.

RWQCB comment: Page 10, paragraph 4. Well Nos. 15 and 16 provided water for the residents of the community of Gold River, especially prior to the development of the industrial area and the construction of Well No. 21.

CDHS response: The proposed dose reconstruction will more accurately explore this comment.

RWQCB comment: Page 13, second paragraph. Insert a "the" after "actions" in the second line.

CDHS response: There was a grammatical problem in the sentence, which we have corrected.

RWQCB comment: Page 13, First Planned Action. September has already passed. Has the ATSDR representative already come out for the visit?

CDHS response: Unfortunately the ATSDR has been delayed in responding to our request for assistance. We have revised the text to indicate a visit is expected.

RWQCB comment: Page 14, Item No. 4. Delete the verbiage in the parenthesis since it was already covered in Item No. 3.

CDHS response: We have deleted the repetitive information.